TRansportation ANalysis SIMulation System
(TRANSIMS)

Portland Study Reports

VOLUME ONE—INTRODUCTION/OVERVIEW

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Volume One: Contents

1. Introduction and Purpose of the Portland Study

This document provides a high-level overview of the features of the TRANSIMS software package that were used in the Portland Study. This is the first in the set of Portland Study documents. The full set of documents explains the capability of TRANSIMS as applied in the Study by describing the preparation of the input data, the software methods that used this data, and the output data produced by the software. This set of documents does not provide a detailed algorithmic description of the software methods. These more detailed descriptions are provided via the Internet at http://transims.tsasa.lanl.gov.

TRANSIMS is not a model. It is a modeling system that permits the modeler to keep track of and modify the behavior of each individual in a synthetic population. The TRANSIMS technology consists of software modules and file protocols that make this modeling possible.

The purpose of the Portland Study is not to develop a complete calibrated model of 1996 Portland. Rather, it allowed the developers of the system to understand transportation planning methods and the models and data that support these methods. Additionally, there are three demonstration purposes of this study:

1) To show that the software runs for a regional problem (Portland, with every street represented) on available computers in a reasonable amount of time (less than 24 hours for each module).

2) To show that TRANSIMS can be made responsive to the variables and conditions that planning organizations deem to be important, and that models produced by TRANSIMS may be calibrated for use in a forecast setting. For example, are modules responsive to the variables that influence mode choice such as downtown parking costs, availability of transit service, and household income? Can TRANSIMS be made to match screen line counts such as bridge crossings in the base case year, and can the “validation constants” obtained for these matches be used in a forecast setting? These calibrations use meta-methods and methods that are external to TRANSIMS and are not part of the core TRANSIMS technologies. Meta-methods and methods are described in Chapter Five (*The Computing Environment*) of this document.

3) To show that it is possible to develop TRANSIMS meta-methods and methods that would allow matches to Portland traffic and transit counts for a base year. In transportation planning exercises, it is critical that the base year be calibrated to existing conditions. In this particular Study, however, the actual calibration is less important than demonstrating working and responsive software and methodologies. There are two reasons for this. First, as in any planning study, it is time consuming and expensive to determine the calibration constants to validate the model for the base year. The limited resources for this study were better utilized in the development of calibration methods rather than fine tuning the models and the input data. Second, a calibration or validation of a base year depends on the metropolitan region being

studied, the base year scenario, and the input data such as the network transit schedules and land-use. The "calibration" constants derived in this study will have to be regenerated for other studies in other metropolitan regions and even studies for Portland Metro. The main goal of this exercise is to develop methodologies that permit this calibration and communicate the techniques that would accomplish this goal. If items 1 and 2 above are met, then it is obvious that traffic and transit counts could be matched using the TRANSIMS software modules and methodologies similar to the ones shown here.

Throughout this set of documents it is apparent that the methodology development to choose modes and match screen-line counts is in a testing stage. In some cases, bridge crossing screen lines for example, the first methods developed do not work entirely as expected. These preliminary methods do, however, show that TRANSIMS can be made to reset the resulting activity set such that screen line or mode splits approach the actual counts and, hence, satisfy item 2 above. In critical cases, such as too many vehicles crossing bridges and causing unrealistic traffic jams, the original methods were modified to produce the desired results. In some of these cases, rather than start over, methodologies were developed to refine the results of the original methodology. To save time and resources where the calibration could be improved in non-critical cases, the original methods were not modified if it was clear that only a slight change in methodology was needed.

The complete set of Portland Study Reports documentation comprises seven volumes, of which this is the first. The purpose of these volumes is to document the procedures and methodologies used in the Study and to give guidance to the development of new methodologies where the need arises.

The remaining seven volumes are:

Volume Two *Study Setup: Parameters and Input Data*

The input parameters (called configuration file keys) used to run each of the TRANSIMS modules are described. It outlines the data used to construct the TRANSIMS network. The external inputs to the various modules from external sources are also described.

Volume Three *Feedback Loops*

The basic TRANSIMS philosophy is to do minimal modeling, requiring as little data as possible to start the process. Feedback loops are critical, since they, rather than an econometric model, are the main modeling tools in TRANSIMS. Volume Three describes feedback methodologies to restrict the number of vehicles crossing the bridges in Portland, feedback to stabilize the traffic patterns, and feedback for mode choice.

Volume Four *General Results (not validation)*

As each TRANSIMS module is executed, an output file is generated. Volume Four contains information about each data set produced during the Study. This includes the file sizes, the computer used, the time it took to generate the file, and the external data used by the modules. A description of any transformation made to this data for analysis during the Study is also included.

Volume Five *Environmental Results*

Emissions estimates from the final microsimulation run are presented.

Volume Six *Summary and Forecast Methods*

The results of the Study are summarized in Volume Seven. The validation is discussed, and in those cases where the validation numbers could be improved, suggestions of the revised methodologies are given. The Study itself is for a base year. Forecast methodologies using the calibration constants determined from a base case study are presented.

Volume Seven *Appendix: Scripts, Configuration Files, Special Travel Time Functions*

TRANSIMS has a flexible Framework that allows for the construction of various models of transportation systems. Some of these systems are constructed by using information from a data set from one TRANSIMS module to change some of the input conditions of a different (or the same) module. A calibrated model is built from the basic TRANSIMS building blocks in this way. Volume Eight contains the scripts, configuration files, and special functions that were applied to produce the final results of this study.

2. The Input Data

While collating data collected for other purposes to make it compatible with TRANSIMS was a tremendous chore, only existing data were used in this study. No new data collection efforts were undertaken by Portland Metro to support the Study. Some of the data supplied by Metro, such as zone-to-zone travel time tables, could have been generated from TRANSIMS results. Other data, such as the activity survey data, is basic input to models of travel behavior other than TRANSIMS.

The most time consuming data preparation for this study was the development of a roadway network that includes

- all local streets,
- land-use characteristics on a block face,
- lane connectivity at intersections,
- intersection signalization, and
- transit schedules, routes, and stops.

The daunting task of constructing the detailed TRANSIMS network for the Portland Study was made simpler by using automated procedures to generate the lane connectivity. Additionally, generic traffic signals, described in Volume Two (*Study Setup: Parameters and Input Data*), Chapter Five (*Microsimulation*) of this series, were used throughout the study. Full detail of the network generation is given in Volume Two (*Study Setup: Parameters and Input Data*), Chapter One (*Network*) of the Portland Study reports. It should be noted that the commercial version of TRANSIMS will contain a network editor that will ease the task of network construction.

Portland Metro's two-day activity survey was used extensively in this study. Data from the first day of the survey for 3,473 households, out of the 5,863 households in the complete survey, were used to support the TRANSIMS Activity Generator. This use is described in Volume Two (*Study Setup: Parameters and Input Data*), Chapter Three (*Activity Generation*) of this series. Some calibration target values, such as the number of work tours that cross the Columbia River, were estimated by Portland Metro using the entire survey data set.

Itinerant traveler and truck trips were generated using trip tables supplied by Portland Metro. This is described in Volume Two (*Study Setup: Parameters and Input Data*), Chapter Three (*Activity Generation*) of this series.

Zone-to-zone travel times by mode and time of day could have been generated using the results of a TRANSIMS analysis. Here, however, existing zone-to-zone travel time tables were used. More information is in Volume Two (*Study Setup: Parameters and Input Data*), Chapter 3 (*Activity Generation*) and Volume Three (*Feedback Loops*), Chapter Two (*Calibration of River Crossing Screen Lines*) of this set of documents.

3. The Modules

TRANSIMS consists of a series of building blocks, or modules, that produce populations, activities for the populations, routes for travelers, and microsimulated traffic dynamics. This Framework is shown in Fig. 1, which shows each of the modules and a series of arrows. The arrows give the possible pathways to transfer data from one module to another. The TRANSIMS Framework allows these modules to be executed in any desired order by a set of scripts. As each module in the Framework is executed with scripts, selected data is collected in an iteration database to be used by the other modules. This allows for information from, say, the microsimulated traffic dynamics to be fed back to the Route Planner to produce a new set of more realistic routes for selected travelers. Feedback of information from one module to another is important in TRANSIMS because it allows the results to be modified and fine tuned to produce realistic traffic and transit dynamics in the system. The feedback possibilities are shown by the red arrows in Fig. 1 The use of these feedback pathways is discussed in the next chapter of this document. Feed-forward data transfers are shown by the black arrows. A complete description of the algorithms and these pathways is available on the TRANSIMS web site.

A major TRANSIMS technical feature is that the identity of individual synthetic travelers is maintained throughout the entire simulation and analysis architecture. All synthetic travelers are generated as part of the development of a synthetic population for a specific metropolitan region using a variety of data sources including census, surveys, etc. Activity times and locations are computed for each individual. The intermodal route plans generated by the Route Planner maintain individual identities, as does the microsimulation. The resulting simulation output can provide a detailed, second-by-second history of every traveler in the system over a 24-hour day. A variety of impact analyses can be conducted using these results. This approach produces a simple, consistent architecture—one that provides planners with deeper insight into the underlying, second-by-second dynamics of the traffic system under different local (e.g., traffic signals) and global (e.g., congestion) conditions.

Fig. 1 illustrates that the various modules of TRANSIMS may be called in any order with different inputs. TRANSIMS itself is not a model of a transportation system. Rather, TRANSIMS is a modeling system. Models are built using TRANSIMS by determining the order of the calls to the modules, by the information that is allowed to flow from one module to another, and by the meta-methods and methods external to TRANSIMS that manipulate these data to build models. This feed-forward/feedback system is very important and is discussed in the next chapter. A general discussion of the flow of the data transfers between the modules (meta-methods), the order in which the modules are called, and the methods incorporated in the meta-methods is given in Volume Eight (*Modeling in TRANSIMS: Calibration and Application*) of the Version 3.0 documentation. The flow of data between the modules is the model of the system.

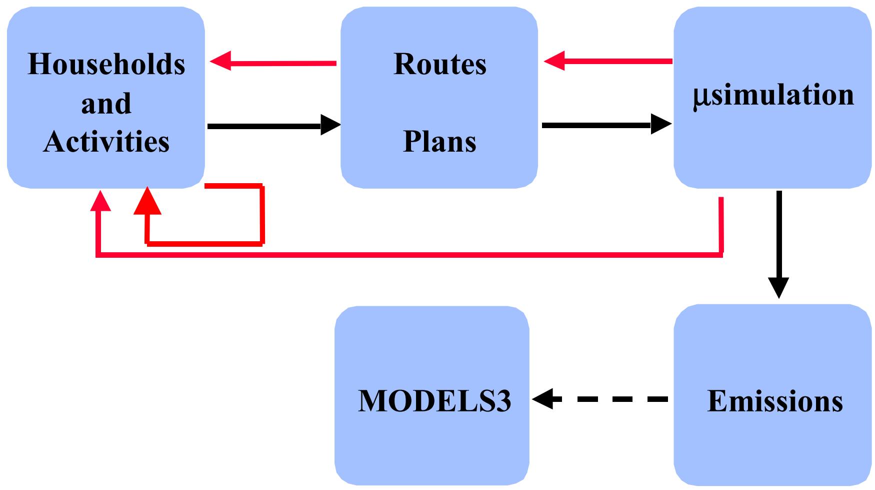

Fig. 1. The highest level view of TRANSIMS consists of four major modules. The modules are household and activity generation, intermodal router, traffic/mobility microsimulation, and an emissions estimator. Feedback based on the modules is used to re-plan and modify activity demand and as a modeling tool. Multiple analyses, in addition to air quality analyses, can be performed using microsimulation results.

4. The Role of Feedback

Feedback and controlling feedback are important functions of the Framework. One of the functions of feedback is to obtain stability in the results. As in assignment methodologies, the Route Planner may place more vehicles on links than the capacity of the link may allow. This may cause congestion to spill back onto other links. Results of the microsimulation in these cases can be fed back to reroute selected travelers to stabilize this situation. The other function of feedback is to model various aspects of transportation systems such as controlling traffic movement across the Columbia River.

In the Study, feedback was used in many capacities. Three of the important ones are:

1) First, as mentioned above, feedback was utilized to stabilize the traffic. The feedback pathways to accomplish this are depicted in Fig. 1 by the black arrow from the Route Planner to the microsimulation and the feedback red arrow in the reverse direction.

2) A feedback methodology was developed to calibrate bridge crossing screen-line counts. This methodology uses feedback between the Activity Generator and itself.

3) The last feedback loop is to correct the mode choice from that given by the Activity Generator. In Fig. 1, this is represented by the black feed-forward arrow from the Activity Generator to the Route Planner and the red feed back arrow in the reverse direction.

These three feedback loops are explained in detail in Volume Three (*Feedback Loops*) of this series of documents.

In TRANSIMS, models are developed from a series of feedback loops between the TRANSIMS modules that changes the behavior of selected individuals in the synthetic population. The order in which the modules are called in one of these loops constitutes a meta-method. Each meta-method has an associated method that controls the changes made to the selected individuals in the synthetic population. Neither the meta-methods nor the methods are part of the core TRANSIMS technology.

Some of the meta-methods and methods used in the study are depicted in Fig. 2. Each of these is described in the following volumes of this Study Report.

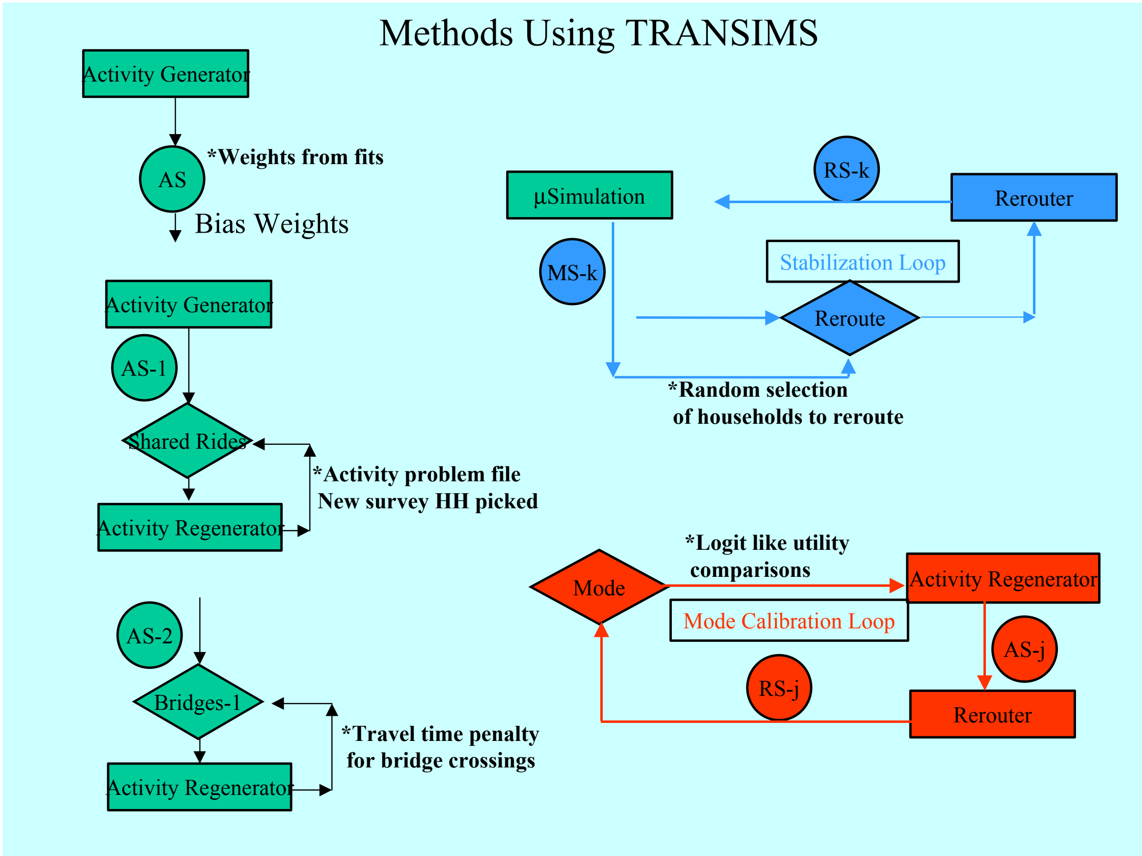

Fig. 2. Data from the TRANSIMS modules are fed back in systematic ways by meta-methods. Each of the meta-methods contains a method for handling the data that is fed back. This picture shows some of the meta-methods and the associated methods (denoted with an asterisk (*)) used in the Study. Both the meta-methods and the methods are external to the core TRANSIMS technologies.

5. Portland Study Flow of runs

Each model using the TRANSIMS technology is a series of feedback loops and the associated meta-methods and methods. The model for the Portland Study is outlined in Fig. 3.

- The circles represent data sets generated by the various modules:
  - AS-* are activity sets,
  - RS-* are route sets, and
  - MS-* are output from the microsimulation.
- The gold symbols (PS-F, AS-F, RS-F, MS-F, MS-E and EM-F) are the final data sets for the population, activities, routes, microsimulation, microsimulation with output for emissions calculations, and the emissions estimates, respectively.
- The diamonds signify the selection of specific individuals or households for changes in their activities or their routes.
- The rectangles are the various TRANSIMS modules.

The diagram shows three types of modeling.

- The green section represents the initial population and activity generation and a series of feedback loops into the Activity Regenerator to refine the initial activity set.
- Feedback between the Route Planner (rerouter) and the Traffic Microsimulator for traffic stabilization is shown by the blue loop.
- The final mode choice feedback loop between the rerouter and the Activity Regenerator is given in red.

Activity sets AS-2 to AS-7 are refinements of the original activity set AS-1. They are each created by selecting specific households from the preceding activity data set and refining their activities. The following is a summary of these activity data sets.

- AS-1—This is the original activity set. The input data to generate this data set is presented in Volume Two (*Study Setup: Parameters and Input Data*), Chapter Three (*Activity Generator*) of this series of reports.
- AS-2—Households with infeasible shared rides were changed to produce AS-2. Activity patterns for households are generated by using the activities from a survey household as the activities of the synthetic household. Shared rides may become infeasible when, for example, the activities of a survey household with two adults and two children are used as a template for a household with one adult and three children. Suppose that in the two-adult household, the second adult spends his/her day taking the children from place to place. In the single adult household, the person to drive these shared rides is not available. Therefore, the shared rides become infeasible. Feasible activity sets are generated in these cases by resampling the survey

households.

The Activity Generator picks the closest school of the appropriate type for children with school activities. If in AS-1, the child walks a long distance to school, the walk mode for that trip is changed to school bus in AS-2. Both the shared ride and school bus changes are discussed in Volume Three (*Feedback Loops*), Chapter One (*Shared Rides / School Buses*) of this series of reports.

- AS-3—The most important screen lines in this study are those that cross the bridges over the rivers. In particular, vehicle trips that cross the Columbia River are critical because there are only two routes across the river. This data set was produced by iterating a penalty function for vehicle tours that cross the rivers. The result of this iteration was fine tuned to produce activity set AS-7. A complete description of this procedure is in Volume Three (*Feedback Loops*), Chapter Two (*Calibration of River Crossing Screen Lines*) of this series of reports.
- AS-4—This activity set was generated by changing the mode from transit to drive where the distance from transit at the destination end was greater than some predetermined distance. A complete description of this procedure is in Volume Three (*Feedback Loops*), Chapter Three (*Experimental Mode Choice and Long Walks*) of this series of reports.
- AS-5—Transit mode was changed to park-and-ride for those transit trips where the origin was far from a transit stop while the destination was close to a transit stop. A complete description of this procedure is in Volume Three (*Feedback Loops*), Chapter Three (*Experimental Mode Choice and Long Walks*) of this series of reports.
- AS-6—If a long walk was requested between activities, the location of the second activity was moved closer to the first. A complete description of this procedure is in Volume Three (*Feedback Loops*), Chapter Three (*Experimental Mode Choice and Long Walks*) of this series of reports.
- AS-7—This data set is a refinement of the bridge-crossing procedure. A complete description of the bridge-crossing procedure is in Volume Three (*Feedback Loops*), Chapter Two (*Calibration of River Crossing Screen Lines*) of this series of reports.

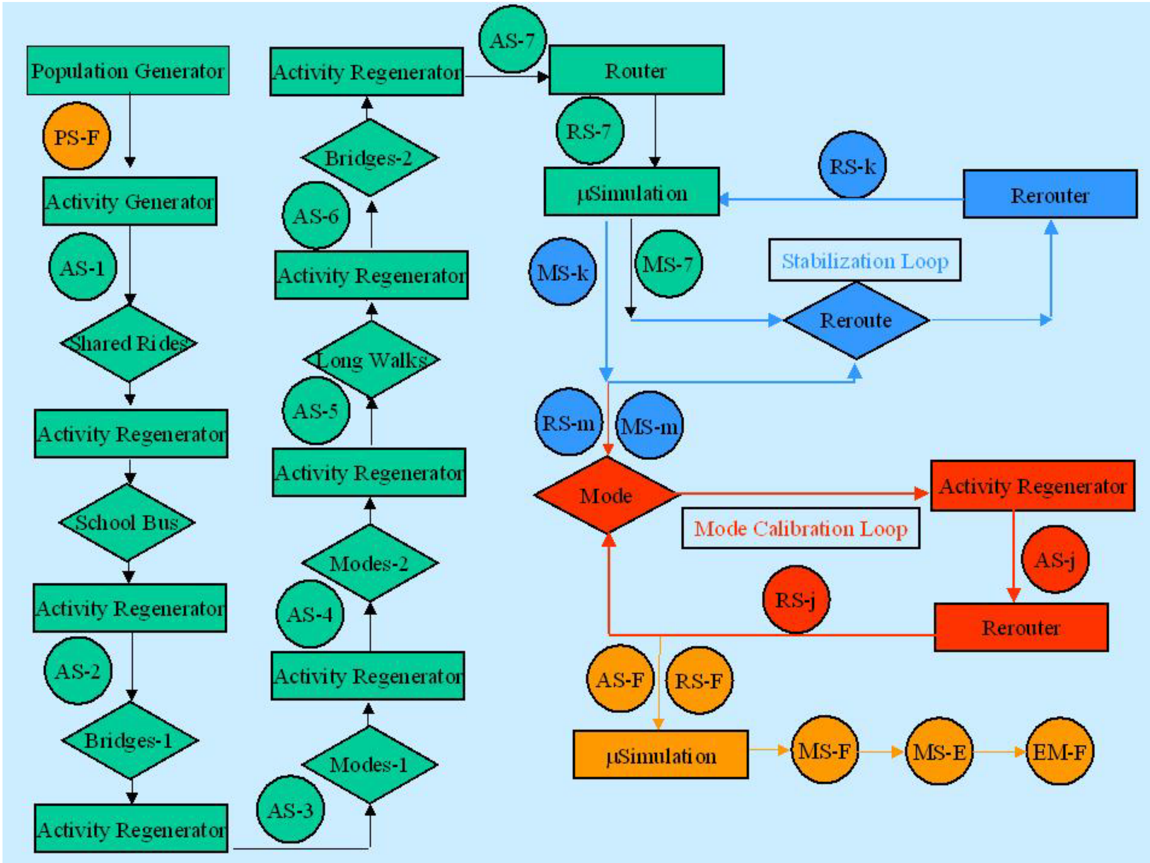

Fig. 3. Each model using the TRANSIMS technology is a series of feedback loops. The model for the Portland Study is outlined in this graph. The circles represent data sets generated by the various modules. AS- are activity sets, RS-* are route sets, and MS-* are output from the microsimulation. The green symbols represent a series of feedback loops through the Activity Generator. Traffic stabilization is accomplished in the blue loop, and mode choice is completed in the red loop. The gold data sets are the final activities, routes, microsimulation and environmental outputs.*

The blue stabilization loop produced route sets, RS-7 to RS-19, and the corresponding microsimulation data sets, MS-7 to MS-19. The stabilization procedure is described in Volume Three (*Feedback Loops*), Chapter Four (*Stabilization*).

The red loop is critical. Iterations between the Route Planner and Activity Generator (activity regenerator) using a set of utility functions produces a calibrated mode split. The procedure for this calibration is given in Volume Three (*Feedback Loops*), Chapter Five (*Mode Choice*).

In an actual study, after the mode selection has been made and the trips routed by the correct mode, the final activity set (AS-F) and route set (RS-F) are produced and are shown in gold in Fig. 3. These are microsimulated to give MS-F. A last microsimulation run is completed where environmental data is collected, MS-E, and the emissions are estimated in EM-F. Here, the emissions were estimated from a non-stabilized microsimulation.

The general results of these simulations are found in Volumes Four (*General Results (not validation)*) and Five (*Environmental Results*). A comparison to Portland data is given in Volume Six (*Comparisons to Portland Data*).

6. The Computing Environment

TRANSIMS modules are designed to use the power of parallel computation to decrease the time required for module execution and to leverage modern computing systems.

Two types of parallel computing systems were used for the Portland Study:

1) Linux cluster using Intel processors from VA Linux

2) Shared memory multi-processor system from Sun Microsystems

6.1 Linux Cluster

Hardware configuration:

- 64 dual-processor nodes with Intel Pentium III 500 MHz processors
- 1 gigabyte of memory per node
- 100 megabit/sec Ethernet connection between the nodes
- RedHat Linux 6.2 operating system (Linux 2.2.16 kernel)
- 100 gigabyte disk accessible from all nodes via NFS

Most of the runs for the Portland Study were made on the Linux cluster because of the number of processors available even though instabilities in this research cluster caused many problems during the study.

6.2 Shared Memory Multi-Processor System

Hardware configuration:

- Sun Microsystems Enterprise 4000 with 14 Ultra Sparc II processors, 248 MHz
- 6 gigabytes of memory
- 300 gigabytes of disk
- Solaris 7 operating system

The Sun Enterprise was used for code development, data analysis, network construction, and computations for the Portland Study that did not require more than 14 processors. This hardware configuration was very stable and delivered consistent performance.

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